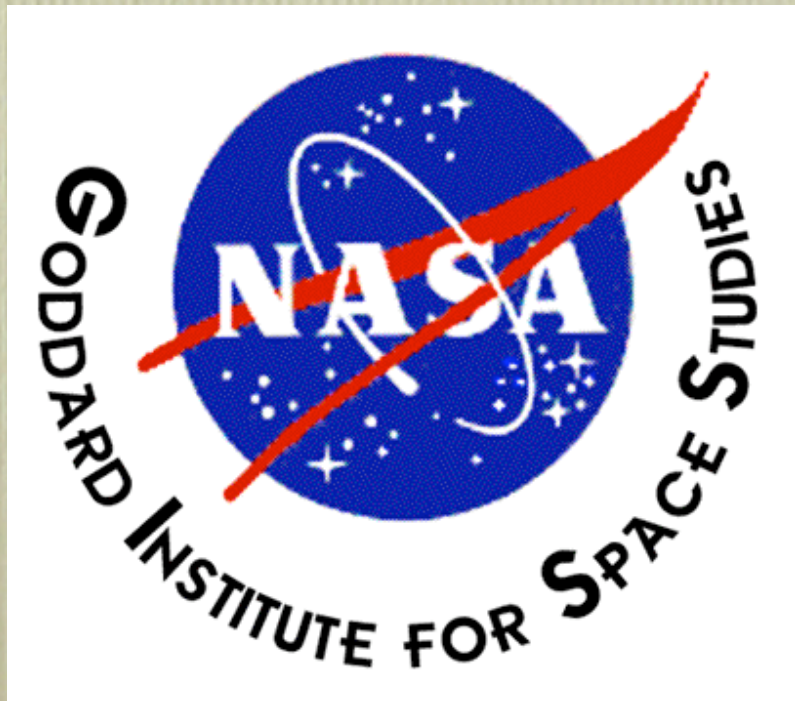


New results from composition and climate modeling at GISS



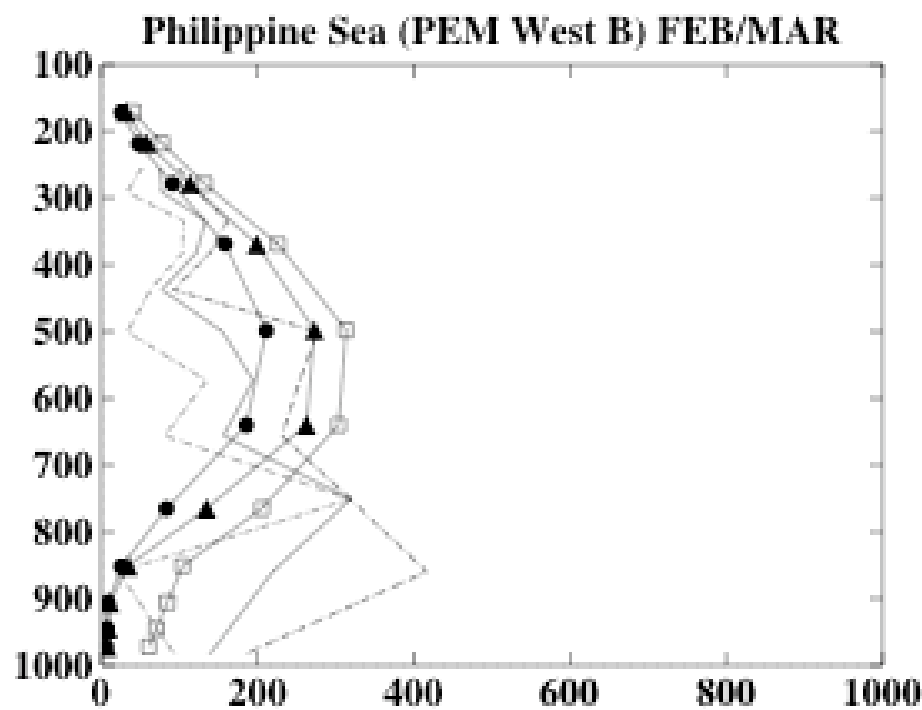
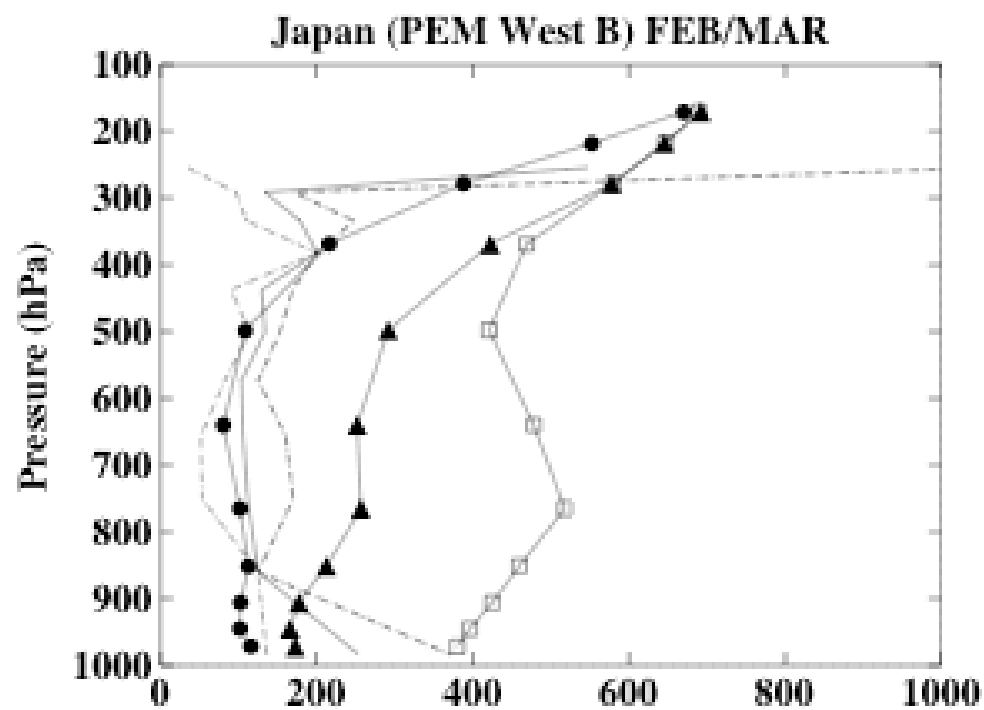
Drew Shindell
&
many co-authors



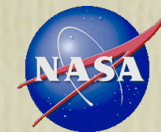
GISS Composition-Climate Modeling

- Trace-gas photochemistry from surface to mesosphere
- Aerosols in troposphere and lower stratosphere
- Fully coupled sulfate and chemistry
- Heterogeneous chemistry on mineral dust
- Stable water isotopes
- Tracers fully interactive with GCM (hydrology, radiation, surface, etc.), advected with second order moments, liquid tracer budget
- 4 x 5 horizontal, 23 vertical layers
- Rms diff vs sondes: 6.3 ppbv (9.3 model II', 10.3 full chemistry modelE, 4.6-17.8 IPCC/ACCENT)

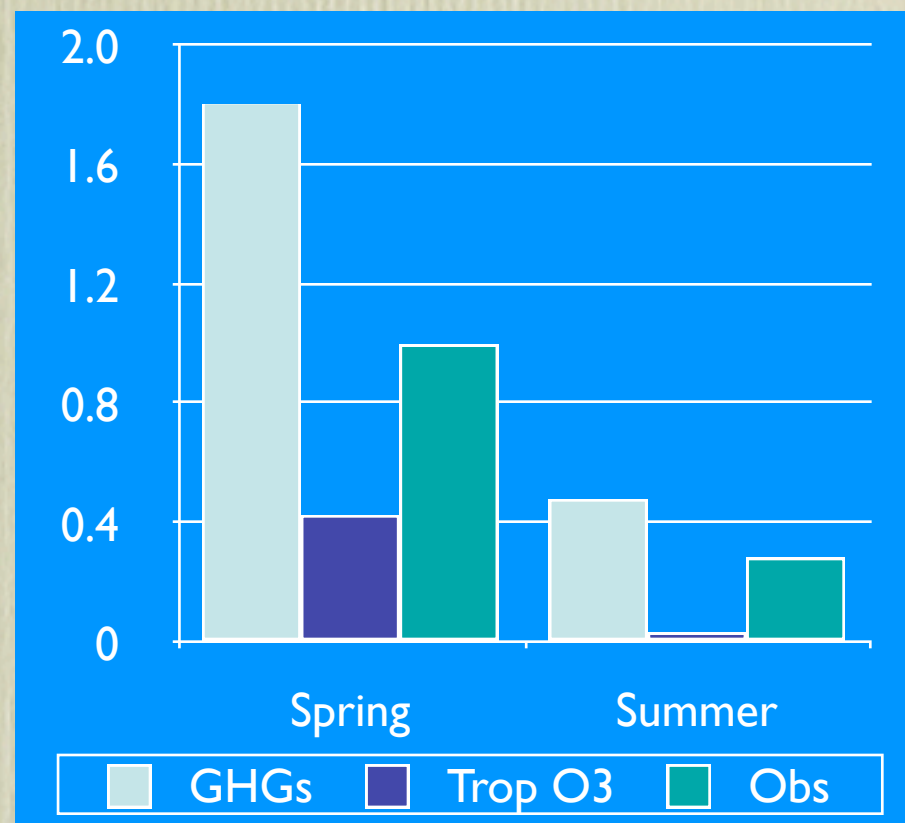
HNO₃ profiles



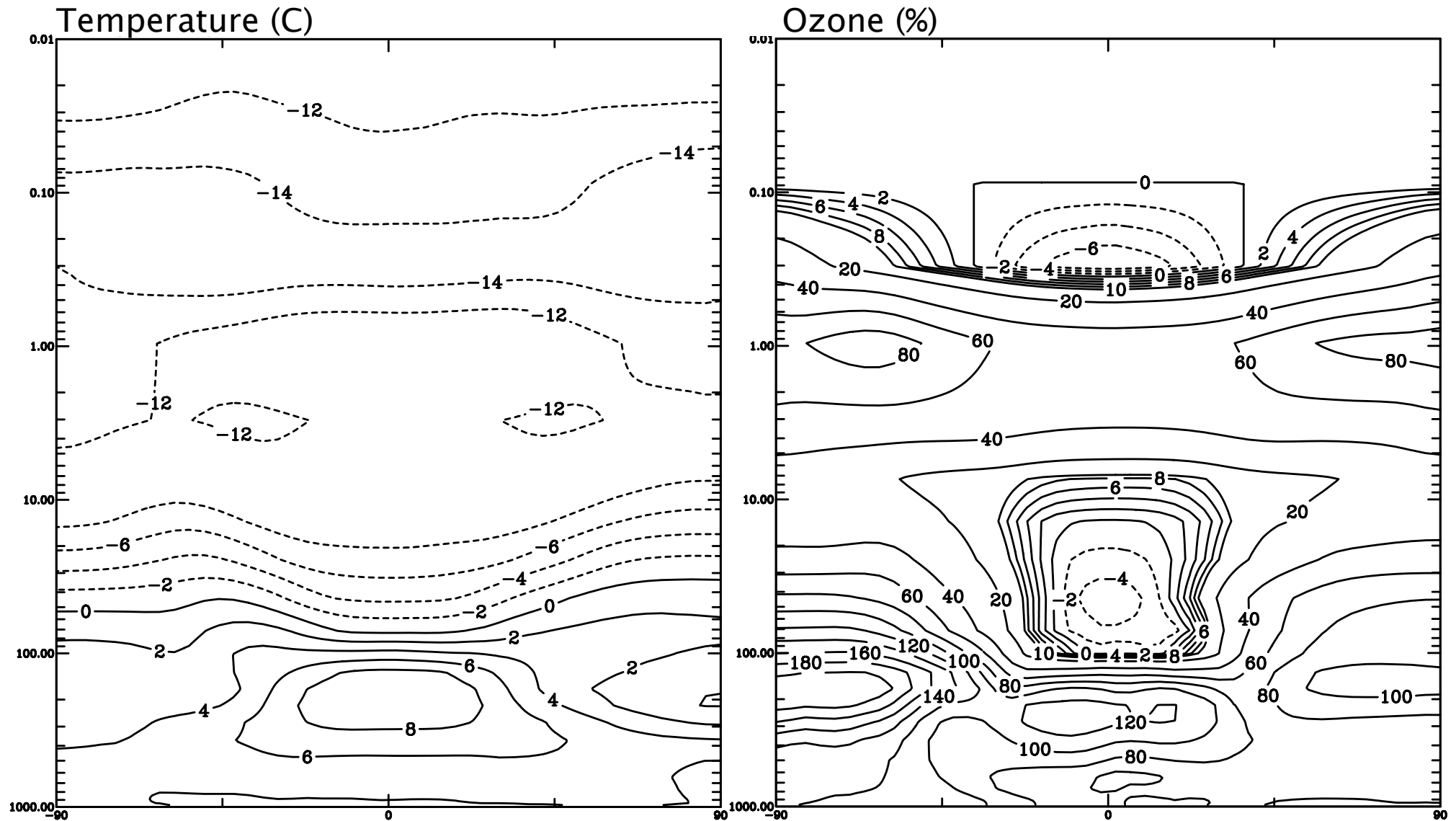
Composition-Climate Results



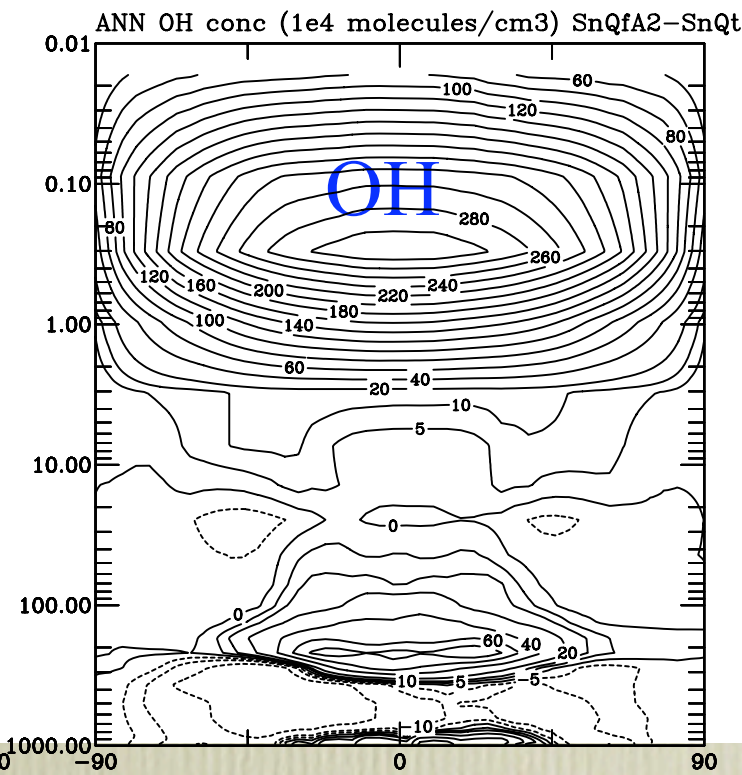
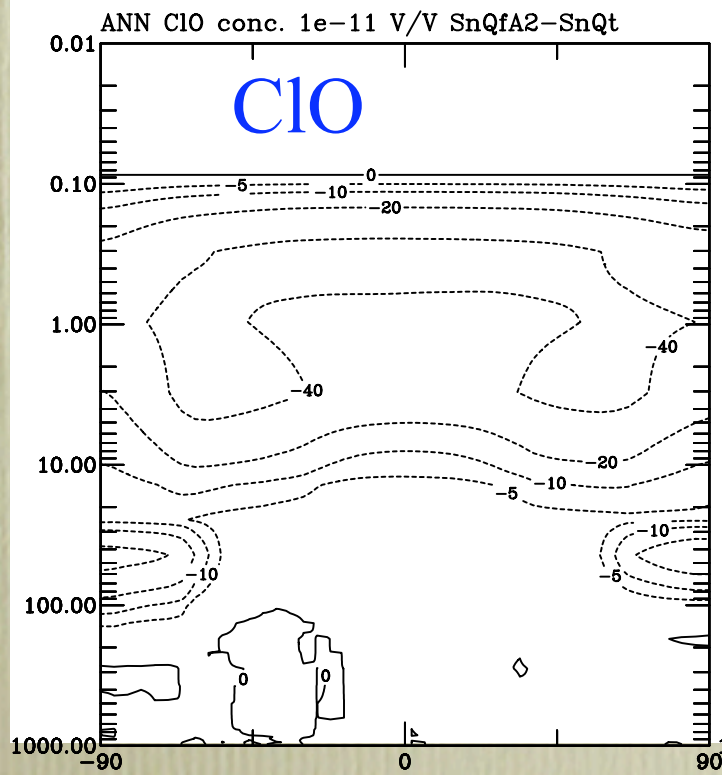
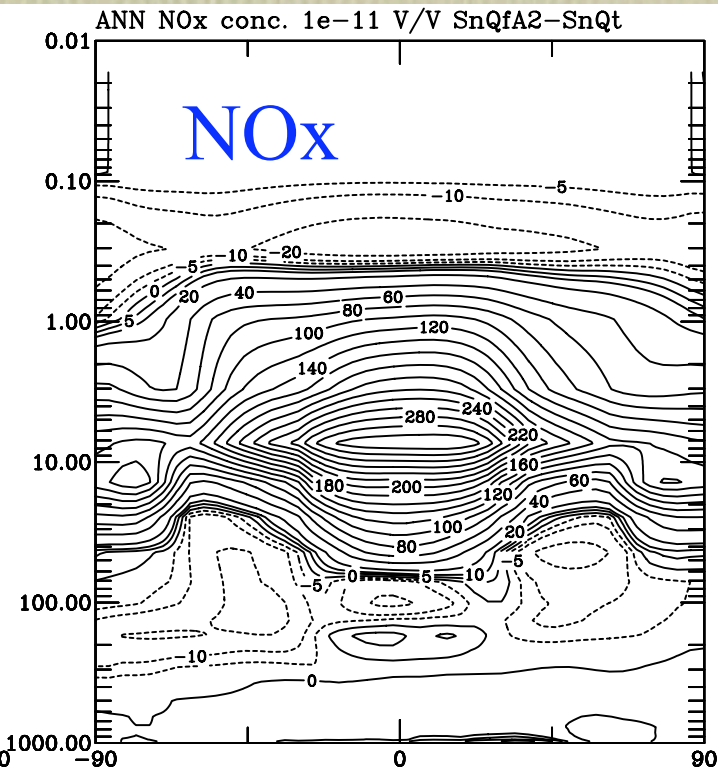
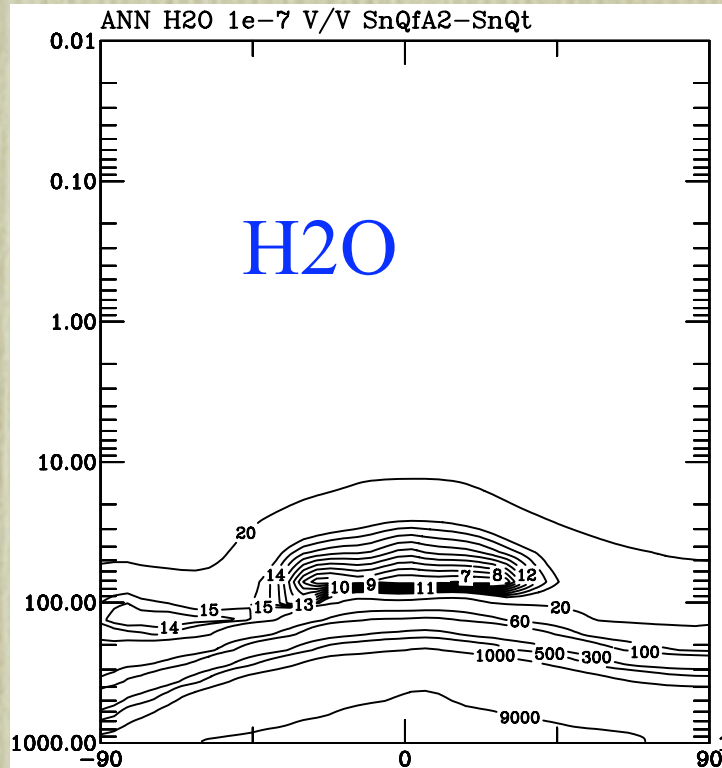
- Sulfur-ozone interactions
 - SO₂ emissions have little influence on RF from ozone
 - Ozone precursors lead to OH, increasing sulphate
 - 2030 case study of ozone precursor emissions:
RF 0.35 W/m² from O₃, -0.61 W/m² from sulphate
- Tropospheric ozone and Arctic warming
 - 1890-2000 IPCC AR4 runs
 - 70-90 N warming (C/century)
- STE response to climate



Annual average 2100 A2 emissions & climate

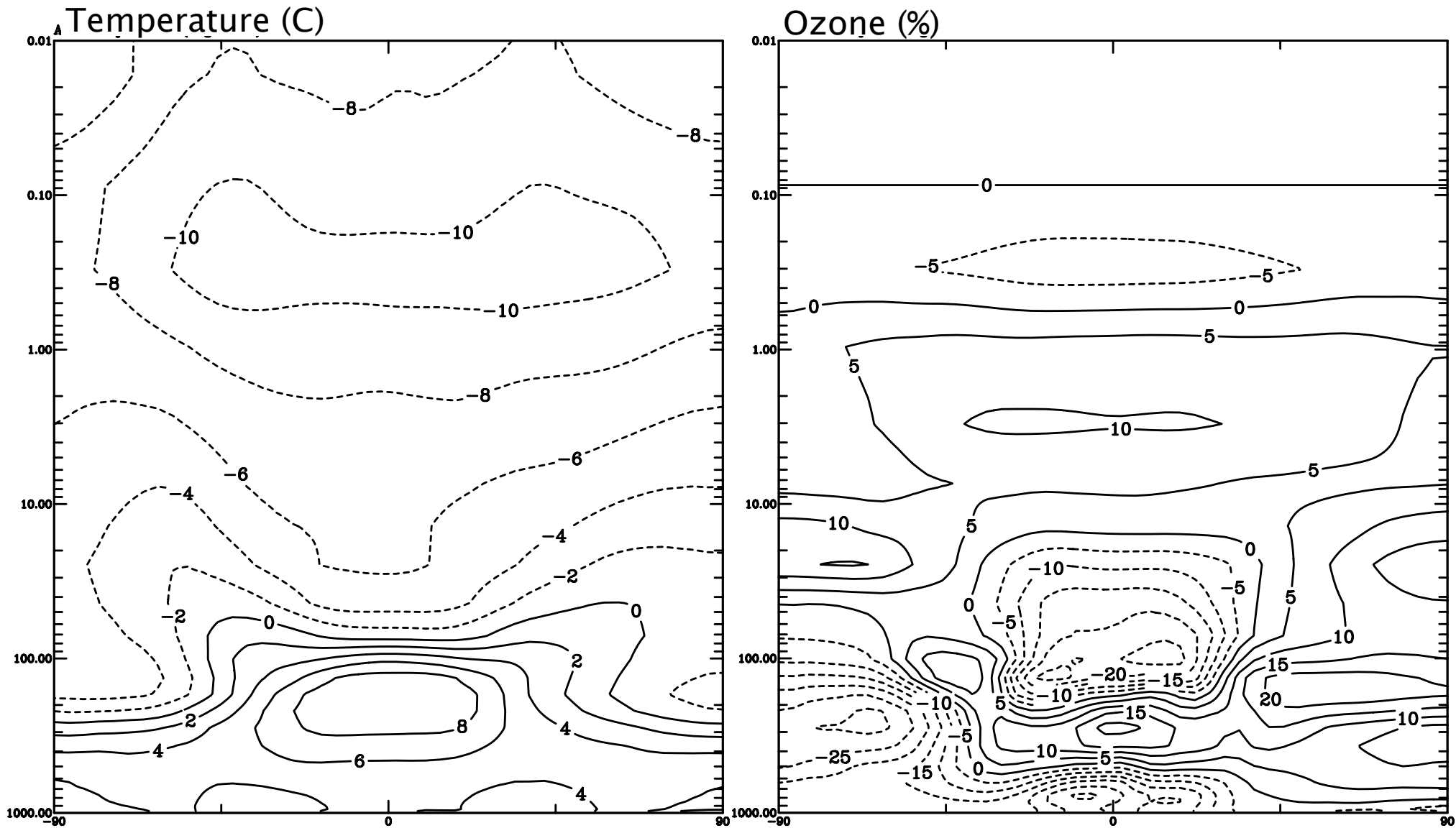
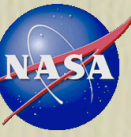


Shindell et al, 2006?

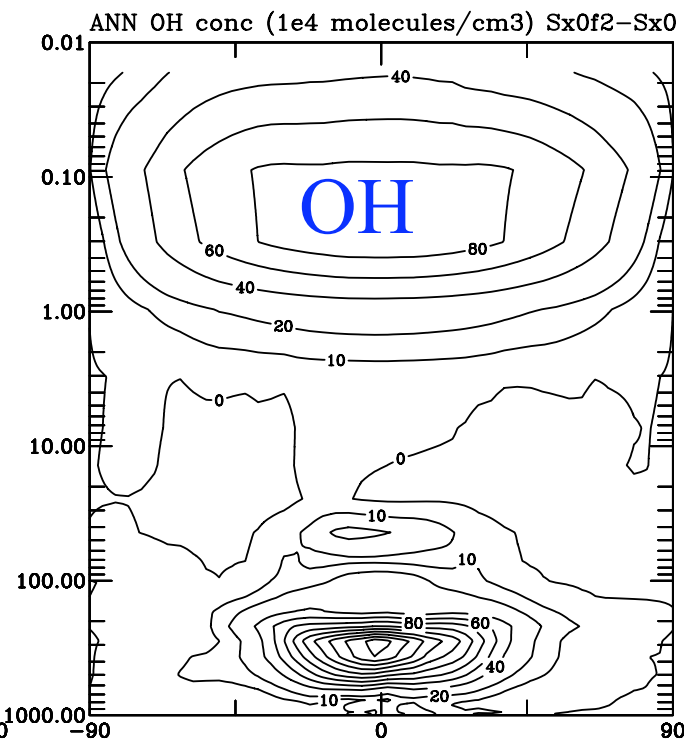
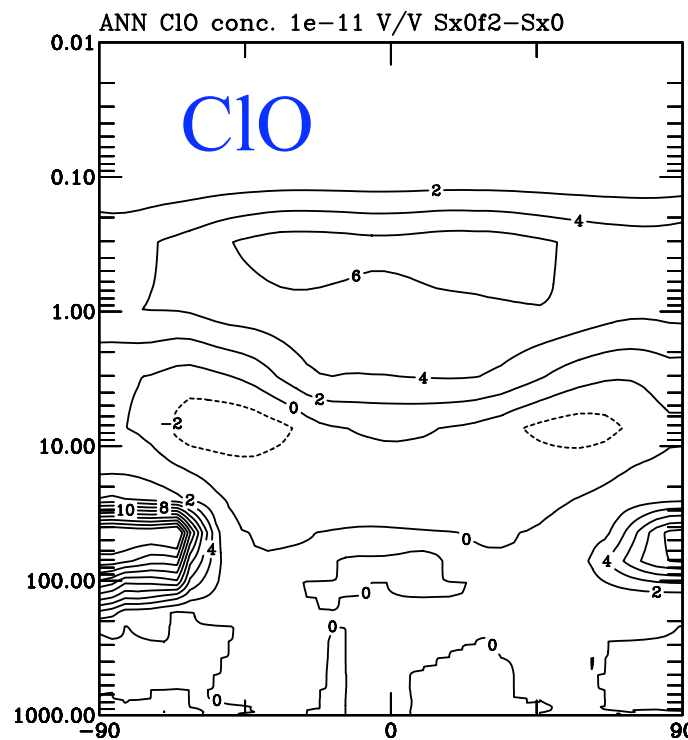
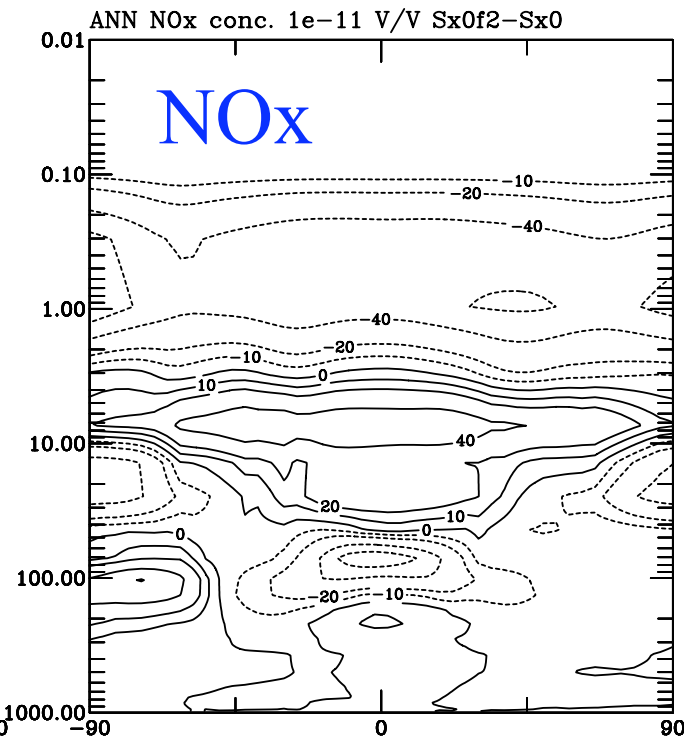
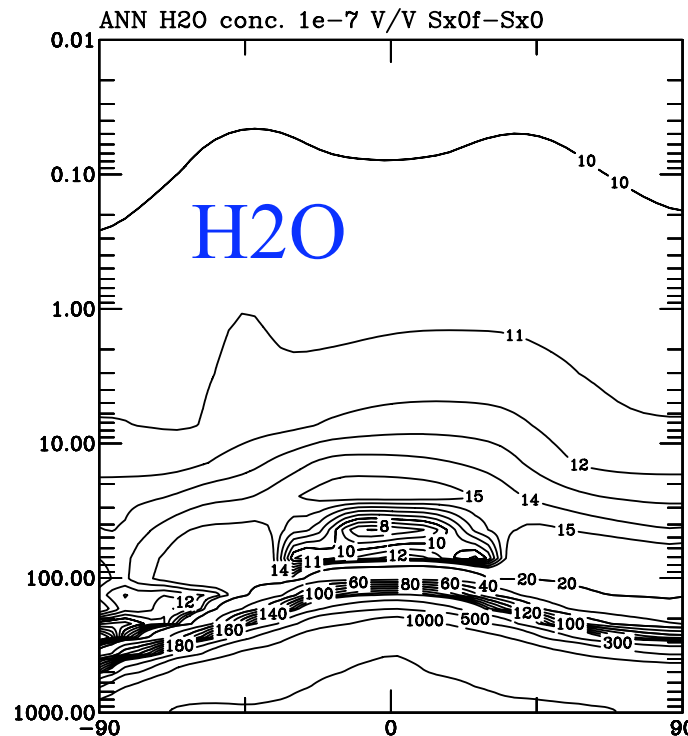


*A2
emissions
& climate*

Annual average 2100 A2 climate only



Antarctic and Arctic opposite!



*A2 climate
only*

PD Ozone fluxes (Tg/yr)

- Murphy and Fahey: 200-870
- Gettleman et al (@100 hPa): 450-590
- Olsen et al (downward extrapolar): 470 (yr 2000)
- 578 at 115 hPa (full chemistry)
- 608 at 150 hPa (full chemistry)
- 502 at 150 hPa (tropospheric chemistry-only)
- NH/SH ratio: NH 57% (Gettleman et al),
55% (Olsen et al); 57% modelE

Ozone fluxes (Tg/yr)

dependence on tropopause definition

PD

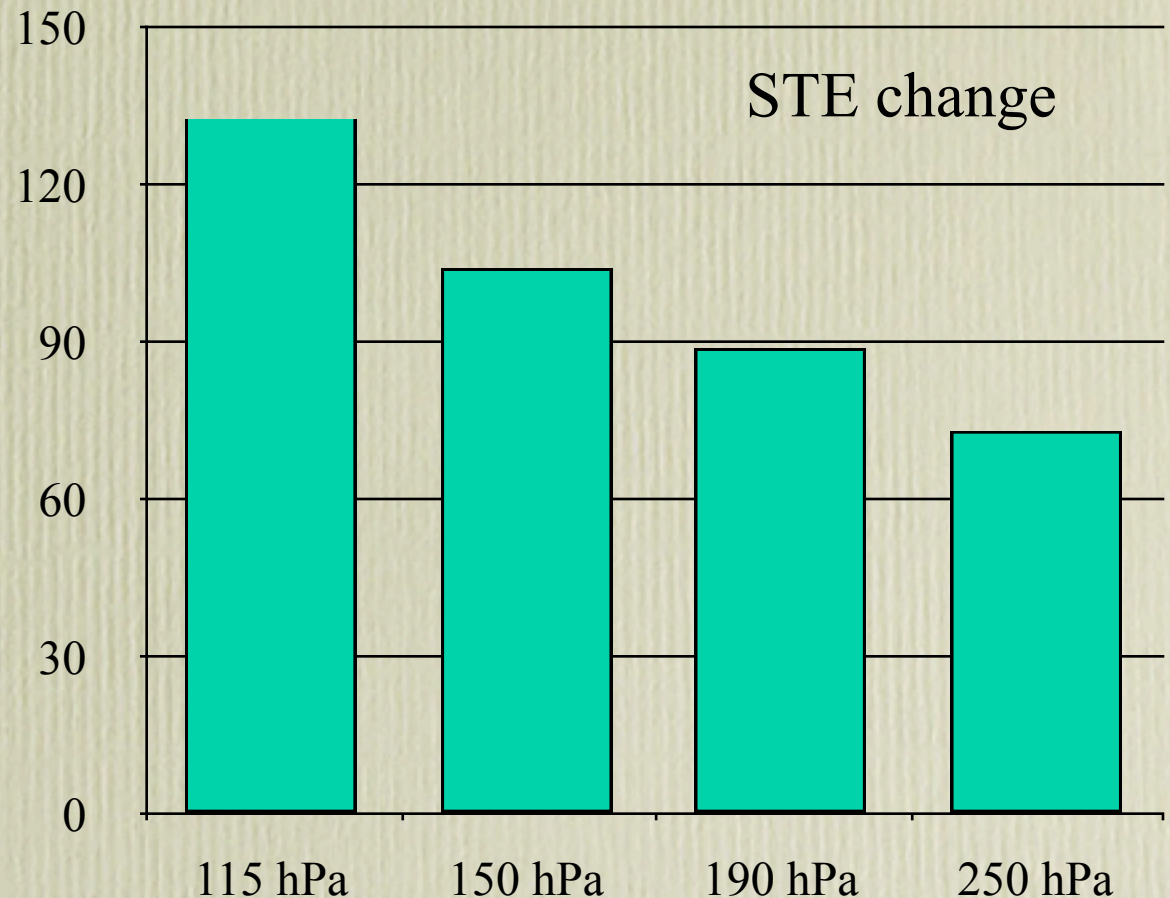
- Global flux at 150 hPa = 608 _____
- Global flux at 150 extratropical, 50 hPa tropics (+horizontal) = 557 _____
- Ozone chemical production in TTL (greater upward flux at 50+horiz. than 150 hPa)
- Global values robust across pressure surfaces (100-250 hPa)
- Tropical and extratropical not always

Ozone flux changes (Tg/yr)

dependence on tropopause definition

PI to PD (large SH ozone loss)

- SH extratropics
 - PI \rightarrow PD
 - 380 \rightarrow 247 at 115 hPa
 - 369 \rightarrow 265 at 150 hPa
 - 319 \rightarrow 230 at 190 hPa
 - 319 \rightarrow 246 at 250 hPa
 - (2-sigma = 32)

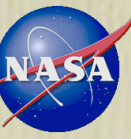


Ozone flux changes (Tg/yr) *dependence on tropopause definition*

PD to A2 2100 climate+emissions

- SH extratropics
 - 247 -> 608 at 115 hPa (+361)
 - 246 -> 663 at 250 hPa (+417)
- NH extratropics
 - 315 -> 690 at 115 hPa (+375)
 - 371 -> 771 at 250 hPa (+400)

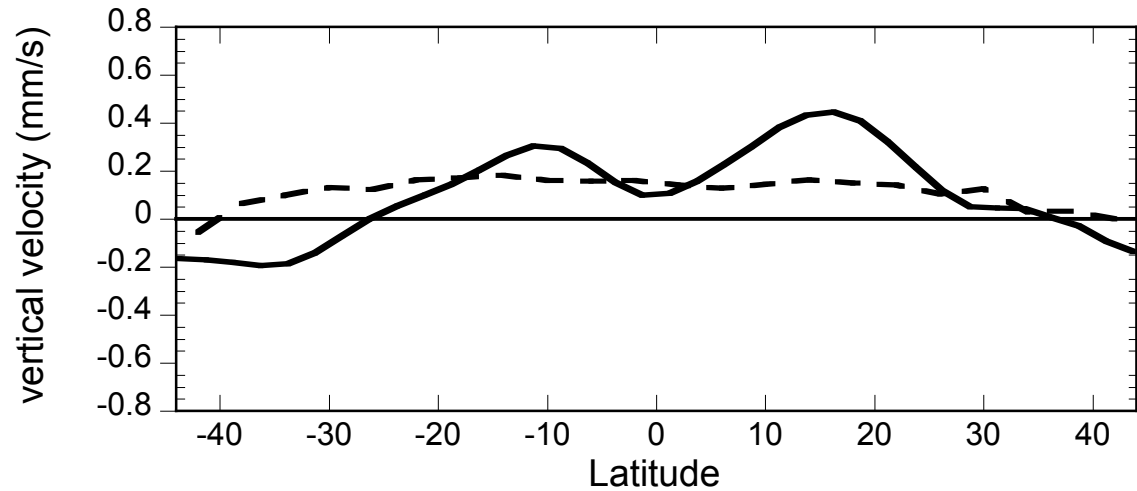
A2 climate: Ozone flux changes (Tg/yr)



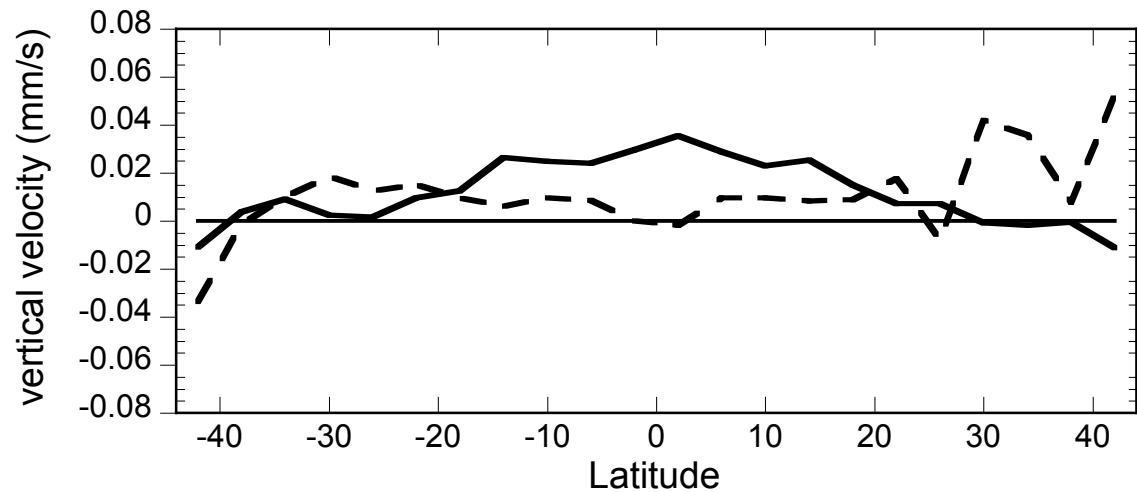
downward across 150 hPa

- SH extratropics 265 -> 269 (A2 2100)
- NH extratropics 353 -> 504 (A2 2100)
- Increase much larger in NH
 - partially due to reduced ozone in lowermost stratosphere over Antarctic
 - primarily due to greater circulation response in NH
- Annual average increase in stratospheric overturning
 - reduction in residence time of gases in stratosphere
 - increased flux into troposphere

Tropical upwelling (68 hPa)



Dashed: model
Solid: UKMO



Dashed: PD to 2100
Solid: PI to PD

*Influence of ozone on lapse rate?
Future: +5%/degree warming*

Conclusions

- STE changes extremely asymmetric NH/SH
- STE values at given time sensitive to pressure surface for regional analysis (not global)
- STE response to climate and emissions depends upon tropopause
- Ozone precursors have potentially larger RF via sulfate than via ozone
- Tropospheric ozone may be powerful lever for affecting Arctic sea-ice